

Saltbox ´ Phase 1
Landlink Estates

Energy Statement
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1 Executive Summary

1.1 Overview

The proposed development Warehouse Unit - Phase 1 at Saltbox, Bognor Regis, consists of a new build B8 warehouse unit. The warehouse comprises of 2810m² of double height warehouse space with 2 floors of offices on the west fa ade.

This report summarizes the energy strategy for the proposed development which has been prepared in line with the Arun Council planning policy. This report follows an energy hierarchy process from ‘Be Lean’ - energy reduction and energy efficiency, to ‘Be Clean’ - Clean use of fossil fuels through district heating, to finally ‘Be Green’ - use of renewable energy.

1.2 Planning Policy Requirements

Energy policies for Arun Council are described within the Arun Local Plan 2011 - 2031 adopted in October 2014. These policies include: ‘Policy D DM1 Aspects of form and design quality’, ‘Policy ECC SP1 Adapting to climate change’, ‘Policy ECC SP2 Energy and climate change mitigation’, and ‘Policy ECC DM1 Renewable energy’. The policy requirements relevant to energy use are summarised as follows:

- ⌘ Developments should meet the requirements of Building Regulations
- ⌘ Developments must be designed using the guiding principles of the energy hierarchy.
- ⌘ Large Developments must produce 10% of their energy from renewable and low carbon sources.
- ⌘ Developments must be designed as to not negatively impact on the surroundings socially, economically or environmentally.

1.3 Energy Strategy

1.3.1 Be Lean - Reduce Energy Demand

The following demand reduction measures have been applied to proposed development;

Passive Measures

- ⌘ Optimising building orientation to maximise sunlight and solar gains

Active Measures

- ⌘ Mechanical ventilation with high-efficiency heat recovery will be provided to the offices
- ⌘ LED lighting and controls throughout
- ⌘ Smart meters to monitor energy consumption

1.3.2 Be Clean - Supply Energy Efficiently

The feasibility of incorporating an on-site heating network or the potential to connect to a local heat network was reviewed. It was concluded that for the following reasons it would not be feasible.

- ⌘ Due to the low domestic hot water requirement and the lack of sufficient space heating load in the summer period, the base heating load would be too low to warrant the creation of an on-site heating network and warrant the use of Combined heat and power (CHP).
- ⌘ There are no existing or planned local district heating networks to connect too.
- ⌘ Localised high-efficiency space heaters such as ASHP’s would reduce complexity in operation and maintenance.

1.3.3 Be Lean - Use Renewable Energy

An appraisal of various renewable energy technology options has been carried out, which identified air source heat pumps as the most appropriate renewable technology to the proposed development. However, there may be potential to connect to a neighbouring solar photovoltaic (PV) farm.

1.3.4 Overall Carbon Savings

The CO₂ emissions for the development have been evaluated against Building Regulations Part L 2013 using the Simplified Building Energy Model (SBEM) v5.3a using DesignBuilder version 5.0.3.007.

Figure 1.1 and Table 1.1 demonstrate the emissions reduction after each stage of the energy hierarchy following the energy reduction measures as summarised above.

Figure 1.1 - Development Energy Hierarchy CO₂ Emissions

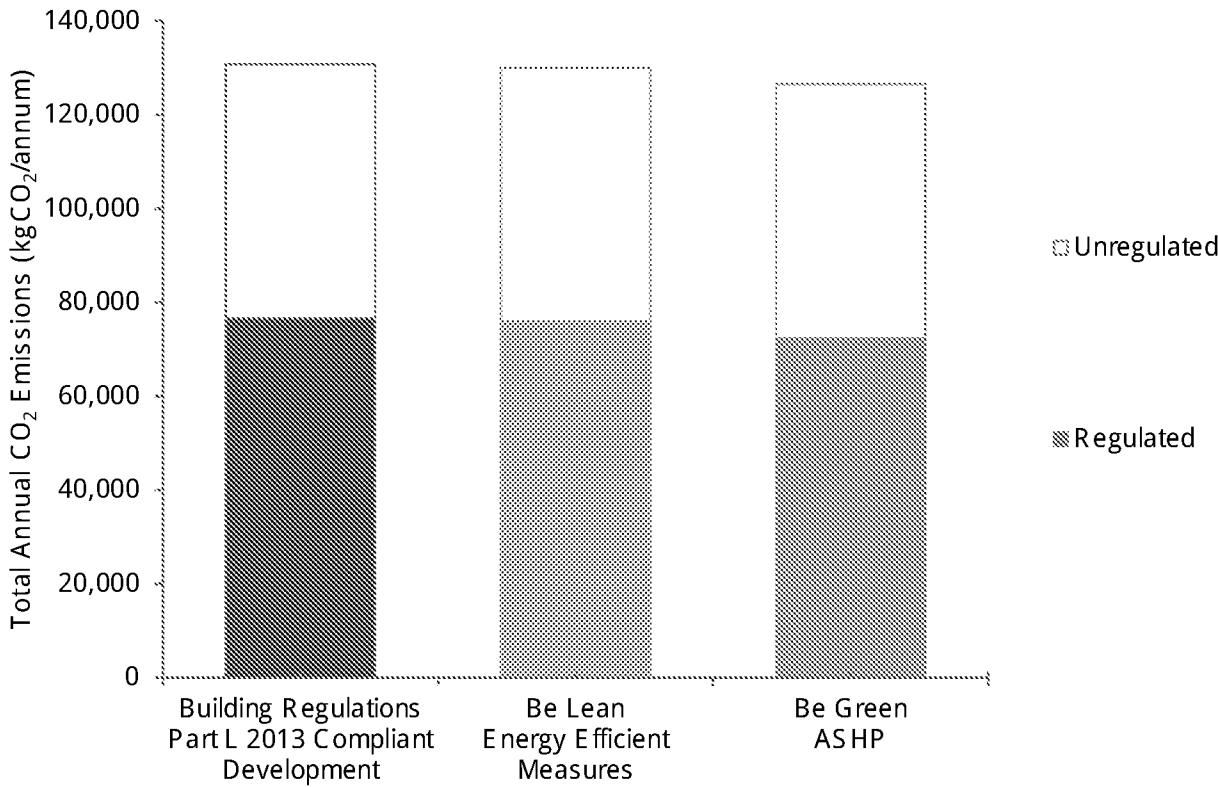


Table 1.1 - Development Total Regulated Energy Demand Summary

Stage of the Energy Hierarchy	CO ₂ Emissions (kg CO ₂ annual)	Percentage CO ₂ Emissions Savings
Building Regulations 2013 Part L Compliant Development	76,575	
After energy efficiency measures savings - Be Lean	75,918	0.9%
After renewable measures savings - Be Green	72,303	5.6%

1.4 Performance Against Policy Targets

The energy strategy was created with the Arun local plan policies as key drivers. Through the application of energy saving measures described in the report, a carbon dioxide (CO₂) saving of 6% has been achieved over the baseline part L compliant development.

2.4% of the developments regulated energy demand has been sourced from a renewable a source, using air source heat pumps (ASHP). There may be the potential to source electrical supply from a neighbouring solar PV farm subject to further investigations and feasibility assessments.

2 Introduction

2.1 Overview

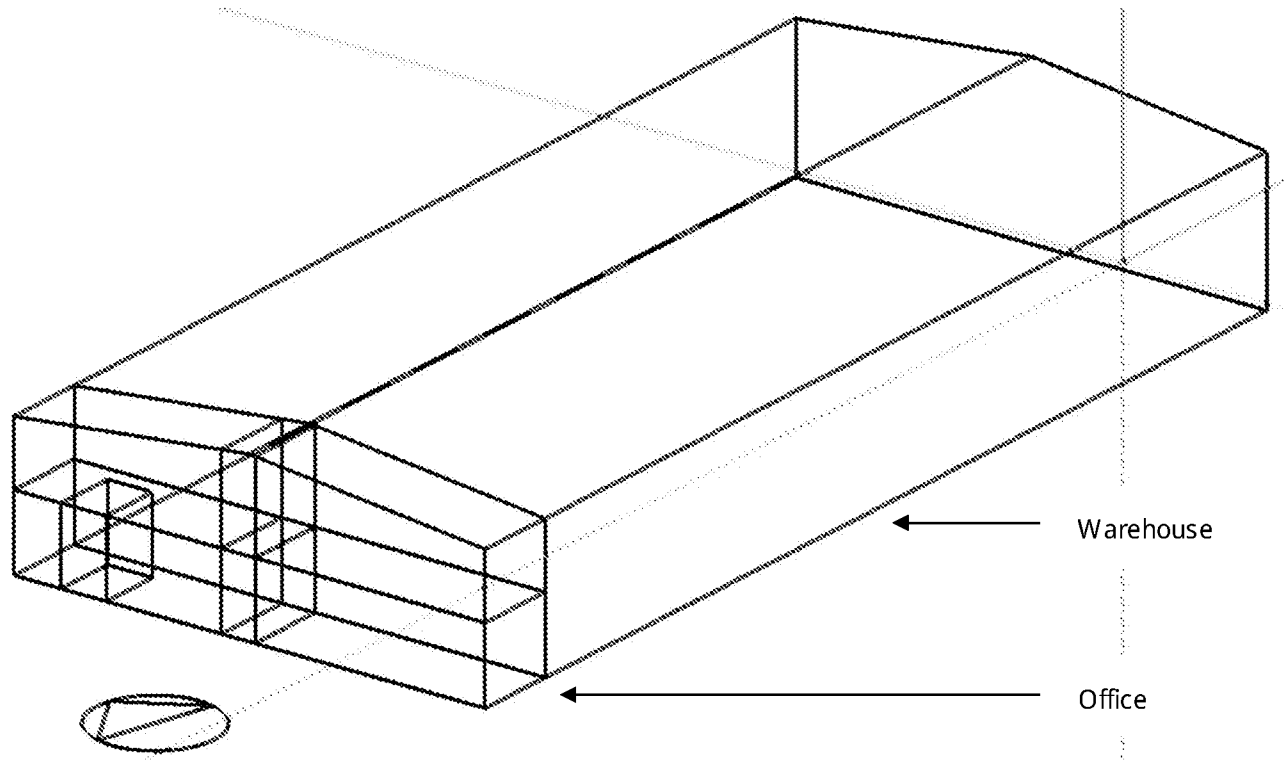
This Energy Statement presents the energy strategy developed by the design team for the proposed development at Saltbox, Bognor Regis. The Energy Strategy follows the typical energy reduction hierarchy to comply with guidance produced by Arun Council.

This Energy Statement should be read in the context of the other planning documents forming part of the planning submission.

2.2 Development Overview

The applicant is seeking full planning permission for the proposed development at Saltbox, which consists of 2810m² of warehouse space and 460m² of office space.

Figure 2.1 ~ SBEM Model of the Proposed Development



2.3 Planning Policy

2.3.1 Local Planning Policy ~ Arun Council

Energy policies for Arun Council are described within the Arun Local Plan 2011 ~ 2031 adopted in October 2014. These policies include: 'Policy D DM1 Aspects of form and design quality', 'Policy ECC SP1 Adapting to climate change', 'Policy ECC SP2 Energy and climate change mitigation', and 'Policy ECC DM1 Renewable energy'.

Policy D DM1 Aspects of form and design quality

This policy sets out the design principles to be taken into consideration. Principle 8 Solar gain will have an impact on the developments energy use.

'Principle 8. Solar gain: Within the constraints of the site and local context development proposals should maximise sunlight and passive solar energy. Ideally development should be positioned (within a 15-20-degree margin) broadly south, with streets having an east-west pattern.'

Policy ECC SP1 Adapting to climate change

This policy sets out how developments could be designed to adapt to climate change. Principles B, C & D will have impacts on the developments energy use:

- b. Water efficiency;
- c. Shade, cooling, ventilation, solar gain;
- d. Connectivity to the green infrastructure network;

Policy ECC SP2 Energy and climate change mitigation

This policy sets out how developments will be designed to promote energy efficiency, how the development will contribute to the reduction in greenhouse gas emissions and how a proportion of the development's energy should be generated from renewable and low carbon sources.

- a. Achieve energy efficiency measures that reflect the standards in Part L of the Building Regulations (or any documentation which supersedes this), or the level of the Code for Sustainable Homes or appropriate BREEAM rating, applicable at the time of submission;
- b. Use design and layout to promote energy efficiency; and
- c. Incorporate decentralised, renewable and low carbon energy supply systems, for example small-scale renewable energy systems such as solar panels.

All major developments must produce 10% of the total predicted energy requirements from renewable or low-carbon energy generation on site unless it can be demonstrated that this is unviable. Energy efficiency measures will be taken into consideration when the total predicted energy requirements are calculated. The Council will consider allowable solutions where it is clearly demonstrated that the provision of onsite renewable or low carbon energy generation is unviable or not feasible.

This reduction in energy use and greenhouse emission should be shown using an energy hierarchy as set out in the DECC 2008 energy act as follows:

- 1 Reduce the use of energy;
- 2 Use energy more efficiently;
- 3 Move to energy from renewable sources; and
- 4 Use remaining fossil fuels cleanly.

Policy ECC DM1 Renewable Energy

This policy sets out how developments should be designed and located to minimise adverse environmental, social and economic impacts. All the relevant principles in this policy have been taken into consideration in the development of the energy strategy

g. For proposals that make use of biomass or energy crops, applicants will need to demonstrate the proposal is appropriately located so that it will not result in the loss of high-grade agricultural land and to the local transport network and that the network has sufficient capacity to safely absorb additional traffic resulting from the development; and

h. All proposals will need to demonstrate a suitable connection to the electricity distribution network, or appropriate energy storage facility, and provide evidence to demonstrate that the connection will not result in unacceptable impacts on the landscape, natural and historic environment or visual and residential amenity.

2.4 Summary of Emission Reduction Targets

To comply with the relevant planning policies and sustainability targets, the proposed development will aim to comply with building regulations and improve upon the with building regulations Part L 2013 as well as aim to achieve 10% of the energy from renewable and low carbon energy sources.

3 Energy & CO₂ Emission Assessment Approach

3.1 Methodology

Regulated and unregulated (equipment) energy use and the associated CO₂ emissions have been estimated using DesignBuilder version 5.0.3.007 SBEM for the Office and Warehouse. The CO₂ emissions are evaluated at each of the three stages of the energy hierarchy. 'Be Lean' - Reduce and use energy efficiently, 'Be Clean' - Using remaining fossil fuels cleanly using district heating, and 'Be Green' - Moving to energy from renewable sources.

The development CO₂ savings reported are based on the outputs from the SBEM BRUKL report using the Building Emissions Rate (BER) and Target Emissions Rate (TER). Where the TER is representative of the notional baseline compliant development energy use.

The CO₂ emissions breakdown by use is not provided in the SBEM BRUKL output reports, (Appendix 4 & 5) only the energy demand. As such an estimate is calculated based on the energy demand and the CO₂ emissions factors given in Table 3.1.

Notional unregulated emissions for the development have been taken from the SBEM BRUKL report as the 'equipment' load, this is deemed more relevant than using benchmarking data (e.g. CIBSE Guide F).

3.2 Carbon Dioxide Emission Factors

The carbon emission factors used in this report are based on those within the Governments SAP Guidance 2012 document and referenced within Building Regulations Part L 2013, given in Table 3.1.

Table 3.1 - CO ₂ Emission Factors	
Fuel	Emission Factor (kgCO ₂ /kWh)
Natural Gas	0.216
Grid Supplied Electricity	0.519
Grid Displaced Electricity	0.519

4 Baseline Energy Consumption

4.1 Baseline Development Emissions

The :baseline~building is a representative model in which the proposed development meets the minimum requirements for CO₂ emissions reduction but goes no further. This is based upon to the Target Emission Rate (TER) defined in Building Regulations Part L 2013. The percentage emissions reduction for each of the :Be Lean~, :Be Clean~, and :Be Green~stages of the energy hierarchy is reported against the baseline emissions outlined in this section.

4.1.1 Breakdown of Energy Consumption and CO₂ Emissions by Use

Table 4.1 provides a breakdown of the CO₂ emissions for the energy demands of the development.

Table 4.1 ~ Baseline CO ₂ Emissions Breakdown by Use	
	Total CO ₂ Emissions (kgCO ₂ /annum)
Electricity	33,534
Heating	41,116
Hot Water	3,464
Cooling	2,831
Unregulated	54,190

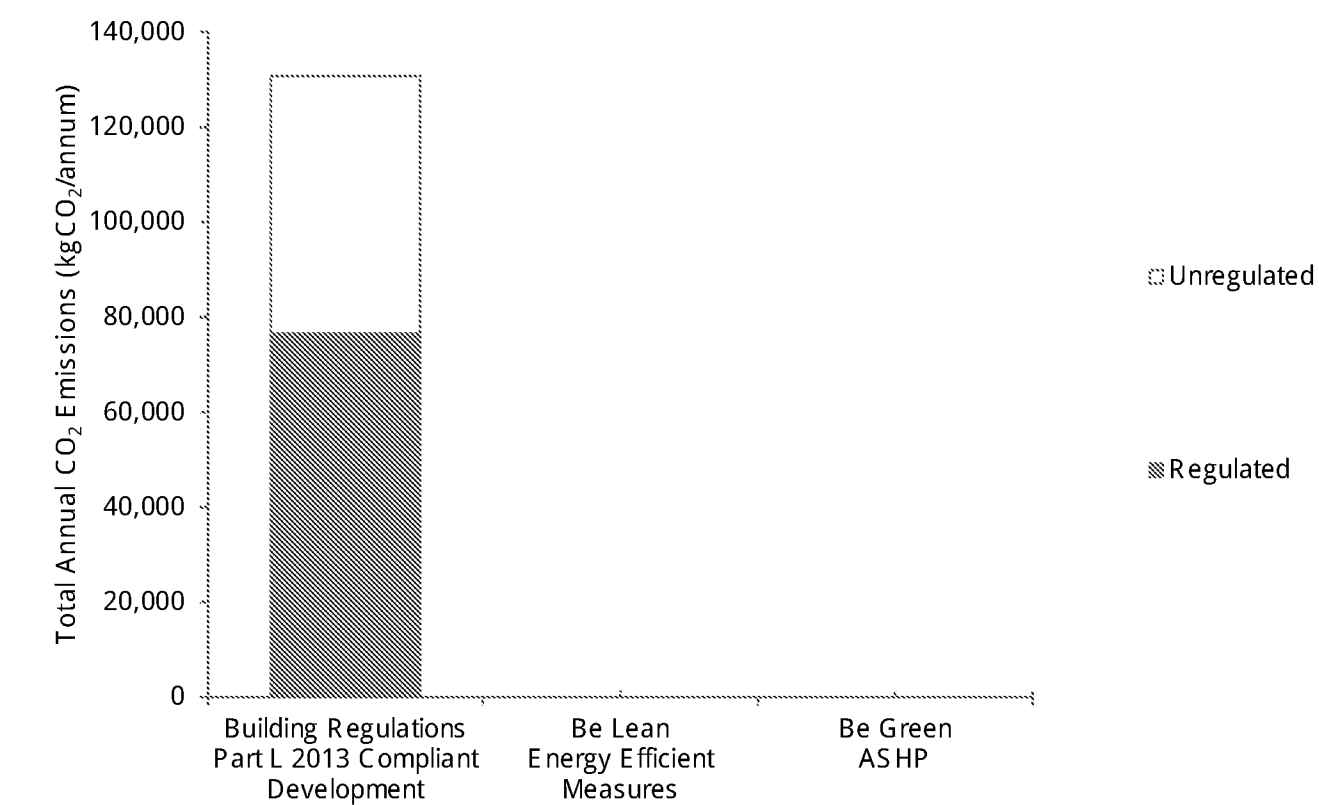
4.1.2 Total Energy Consumption and CO₂ Emissions

Table 4.2 details the CO₂ emissions rate based on the TER as determined from the SBEM assessment.

Table 4.2 ~ Baseline Total Regulated and Unregulated CO₂ Emissions

	Total Floor Area (m ²)	TER (kgCO ₂ /m ²)	Total Regulated CO ₂ Emissions (kgCO ₂ /annum)	Total Unregulated CO ₂ Emissions (kgCO ₂ /annum)	Total CO ₂ Emissions (kgCO ₂ /annum)
Development	3,287	23.30	76,575	54,190	130,765

Figure 4.1 ~ Building Regulations 2013 Part L Compliant Development Emissions (regulated and unregulated)



5 Demand Reduction (Be Lean)

5.1 Overview

The proposed development has been designed from the outset with energy efficiency as a key driver. The project team recognises the need to reduce the energy demand of the proposed development as far as practical through the use of both passive and active design measures.

5.2 Passive Demand Reduction Measures

Passive design features incorporate the use of the building structure and fa ade to minimise heating, ventilation and lighting demand. This includes measures such as improved sun light penetration to maximise natural daylight and limit excessive solar gains to the space.

5.2.1 Building Orientation and Glazing

The building orientation has situated the office towards the south west fa ade. This should reduce the heating requirements during winter months. Similarly, the warehouse rooflights allow natural daylight penetration into the space.

5.3 Active Demand Reduction Measures

5.3.1 Mechanical Ventilation with Heat Recovery

The office ventilation is via a central air handling unit incorporating high efficiency thermal wheel heat recovery. This will reduce heating demand in the winter and cooling demand in the summer. Target and proposed efficiencies are shown below in Table 5.1.

Table 5.1 ~ Heat Recovery in the Office

Element	Notional Building Efficiency (%)	Proposed Efficiency (%)
Thermal Wheel Heat Recovery	65	80

5.3.2 Low Energy Lighting and Controls

It is anticipated that low energy LED lighting would be specified throughout the building both internally and externally to minimise the associated electrical demand. Photoelectric controls are proposed within both the office and warehouse areas to reduce the lighting use, in addition to using high efficiency lighting, as shown below in Table 5.2.

Table 5.2 ~ Building Lighting Efficacy Summary

Element	Reference standard (lm/W)	Proposed value (lm/W)
Office	60	100
Warehouse	60	80

5.3.3 Energy Efficient Heating & Cooling Plant

Energy efficient plant has been selected where possible with improvements over the Non-Domestic Compliance Guide 2013 values as shown in Table 5.3.

Table 5.3 ~ Building Target Plant Efficiencies

Building Services Plant	NDCG 2013 Minimum Efficiencies	Proposed Value	NDCG 2013 Radiant Efficiency	Proposed Value
Multi-burner Radiant Heater to Warehouse	91%	93%	55%	60%
WC Local Extract Fan SFP (W/l/s)	0.5	0.3		
Office Mechanical Vent Fan SFP (W/l/s)	1.9	1.6		

5.4 Lean Development Energy Consumptions and CO2 Emissions

The 'Be Lean' development emissions are estimated using a scenario where the heating provision to the office is by gas boilers and radiant heaters to the warehouse. It is expected that low energy appliances are installed throughout, however without further information at the time of writing only the baseline unregulated emissions are reported.

5.4.1 Breakdown of Energy Consumption and CO2 Emissions by Use

Table 5.4 provides a CO2 emissions breakdown by use of the regulated energy demand after applying 'Be Lean' measures for the development.

Table 5.4 ~ 'Be Lean' CO2 Emissions Breakdown by Use

	Total CO2 Emissions (kgCO2/annum)
Electricity	26,182
Heating	48,137
Hot Water	2,996
Cooling	1,535
Unregulated	54,190

5.4.2 Total Energy Consumption and CO₂ Emissions

Table 5.5 details the CO₂ emissions rate based on the BER (i.e. the calculated CO₂ emissions emitted by a non-domestic building) values as determined from the SBEM assessments.

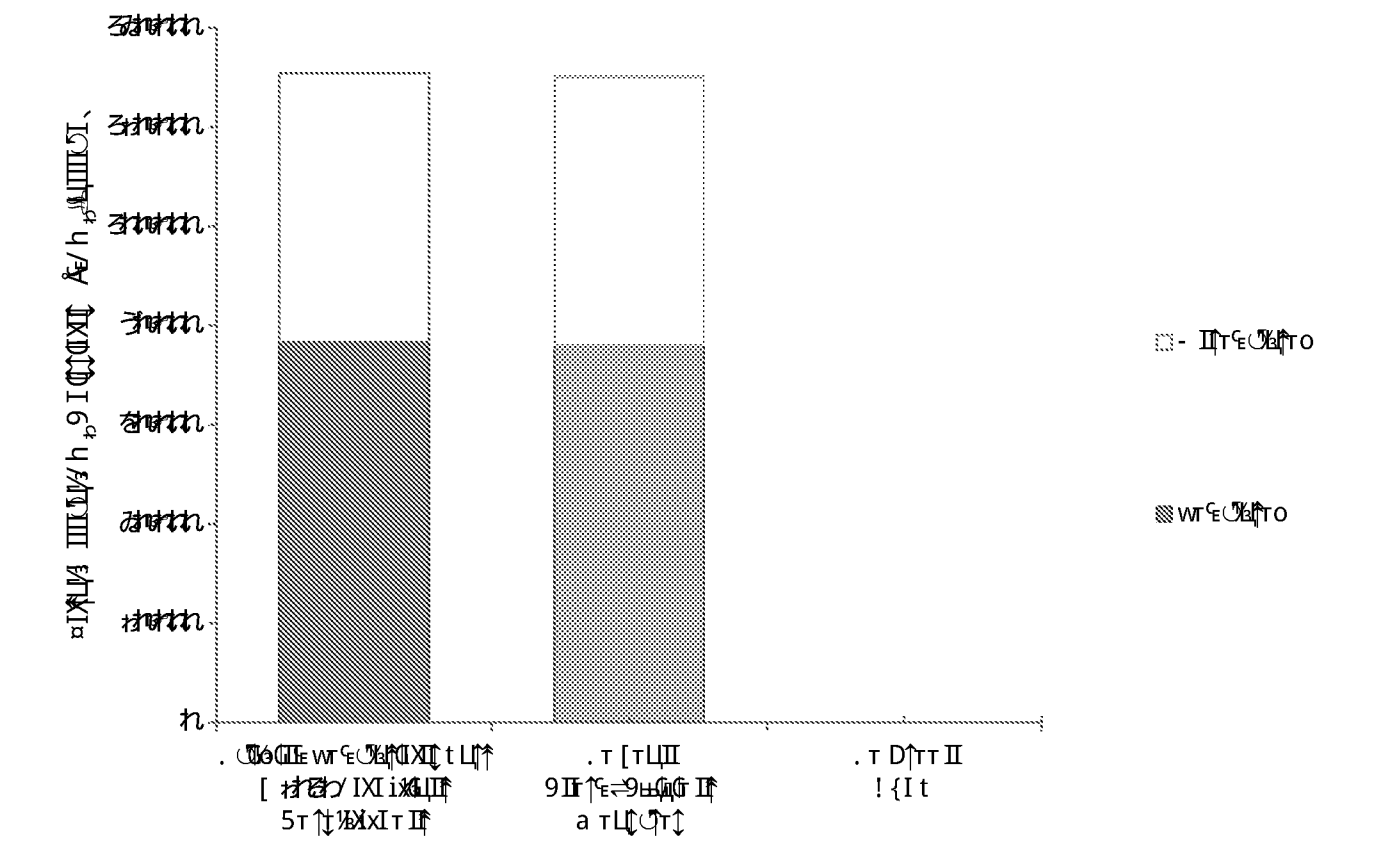
Table 5.5 - Be Lean™ Total CO₂ emissions

	Total Floor Area (m ²)	BER (kg CO ₂ /m ²)	Total Regulated CO ₂ Emissions (kg CO ₂ /annum)	Total Unregulated CO ₂ Emissions (kg CO ₂ /annum)	Total CO ₂ Emissions (kg CO ₂ /annum)
Proposed Development	3,287	23.10	75,918	54,190	130,108

Table 5.6 - Be Lean™ CO₂ Emissions Savings

	CO ₂ Emissions (kg CO ₂ /annum)	Percentage CO ₂ Emissions Savings
Building Regulations 2013 Part L Compliant Development	76,575	
After Energy Efficiency Measures	75,918	1%

Figure 5.1 - Comparison of Building Regulations 2013 Part L Compliant Development and Be Lean™ Development (regulated and unregulated emissions)



6 Centralised Energy and CHP (Be Clean)

6.1 Overview

:Be Clean~ measures include connection to district heating systems and local energy generation technologies, in particular Combined Heat and Power (CHP). The typical selection hierarchy is shown below.

1. Connection to existing heating and cooling networks.
2. Site wide CHP network.
3. Communal heating and cooling.

6.2 Connection to Existing District Heating Networks

An assessment has been carried out to establish the feasibility of connecting the proposed development to a current or proposed district heating network in the area. It has been determined that there are no existing heat networks within the vicinity of the site.

6.3 Centralised Heating Infrastructure ~ Combined Heat and Power

The feasibility of incorporating an on-site heating network or the potential to connect to a local heat network was reviewed. It was concluded that for the following reasons it would not be feasible.

- ⌘ For CHP systems to operate efficiently there must be baseload requirement for heating year-round. Since the demand for space heating is seasonal the baseload is usually determined by the domestic hot water requirement. The hot water demand for the site is too low to warrant use at a CHP level
- ⌘ There are no existing or planned local district heating networks to connect too.
- ⌘ Localised heat sources such as air source heat pumps offer a high efficiency alternative to a centralised system with reduced complexity in operation and maintenance.

For these reasons, it has been concluded that heating provision via a centralised heat network would not be viable for the proposed development

7 Renewable Energy (Be Green)

The last stage of the energy hierarchy is the application of renewable energy technologies. A high level options appraisal was carried out to understand which technologies may be viable for the proposed development.

Certain technology options have been automatically discounted as not viable due to the lack of available resource. These are anaerobic digestion, mid and large-scale wind, and hydro. The benefits and constraints for the remaining renewable technologies are summarised in Table 7.1.

Table 7.1 ~ Feasibility Assessment of Renewable Technologies Application to the Development

Technology	Benefits	Constraints
Biomass Centralised biomass boilers providing heating and hot water to all areas with condensing gas boiler backup	- Biomass is considered a carbon neutral fuel. - Biomass boiler efficiency is approaching that of an equivalent natural gas boiler.	- Large space requirements for fuel store and buffer tank - Access required for regular fuel deliveries and ash removal. - Reliable fuel source required. - Increased quantities of NO_x, SO_x and particulates PM₁₀ compared to natural gas. - Suitable for a centralized system only
Ground Sourced Heat Pump (GSHP) Centralised GSHP generating warm water for heating to all areas. Hot water via warm water pre-heat and electric immersion	- GSHP system can provide both heating and cooling. - Higher efficiencies than equivalent gas boiler system. - Qualifies for the RHI scheme - Public outdoor areas could be used for horizontal collector array	- More complex and costly than ASHP - Spatial considerations for horizontal collector array - Initial explorative investigation required for vertical collectors to determine heat yield with no guarantee of viability - Suitable for a centralized system only
Air Sourced Heat Pump (ASHP) Decentralised ASHP generating warm water for heating to all areas. Hot water via warm water pre-heat and electric immersion	- ASHP provide both heating and cooling - Easy to install and maintain compared to GSHPs - Lower cost than GSHP	- Lower COP than GSHP - Extensive external plant space (must be in free air), visual implications for external plant
Solar Hot Water Roof mounted, centralised system providing HWS pre-heat	- Can offset a proportion of the development's heat demand - Simple installation and maintenance	- Added system complexity - Reduces roof space available for PV - Competes with other roof uses. - Not suitable for system of low dth demand
Solar Photovoltaics Roof mounted centralised system with single inverter fed to landlord supply with provision for export of excess of instantaneous demand.	- Low maintenance - Easy to integrate within roof design - Feed in tariff available - Doesn't compete with CHP - Minimum internal plant requirement	- Increased cost with higher efficiency modules - Large roof areas required to achieve notable CO₂ reductions. - Competes with other roof uses.

7.1 Air Source Heat Pumps

Energy efficient air source heat pumps are proposed to deliver heating and cooling to the office floors. Air source heat pumps have been proposed as an appropriate heating technology for the proposed development.

7.2 Photovoltaics

The proposed development is in a good location in the UK for PV. The average annual insolation at the development is near the highest across the UK and Northern Ireland, allowing for optimal generation.

A 5MW farm of a consented 22MW solar photovoltaics farm has been built on a neighbouring development to the proposed development. Potential exists to receive the electrical supply for the development from the PV farm, however this is subject to further investigations and feasibility assessment. At this time, it has been excluded from this analysis.

7.3 Be Green Development Energy Consumption and CO₂ Emissions

The 'Be Green' development emissions are estimated based on the 'Be Lean' measures incorporated with the addition of renewable heating from air source heat pumps.

7.3.1 Breakdown of Energy Consumption and CO₂ Emissions by Use

Table 7.2 provide a CO₂ emission breakdown by use of the regulated energy demand after applying 'Be Green' measures for the development.

Table 7.2 ~ 'Be Green' CO₂ Emissions Breakdown by Use

	Total CO ₂ Emissions (tCO ₂ /annum)
Electricity	26,182
Heating	42,558
Hot Water	2,996
Cooling	1,535
Electricity Generated	0
Unregulated	54,190

7.3.2 Total Energy Consumption and CO₂ Emissions

Table 7.3 details the CO₂ emissions rate based on the BER values as determined from SBEM assessment.

Table 7.3 - Be Green~Total Regulated CO₂ Emissions

	Total Floor Area (m ²)	BER (kgCO ₂ /m ²)	Total Regulated CO ₂ Emissions (kgCO ₂ /annum)	Total Unregulated CO ₂ Emissions (kgCO ₂ /annum)	Total CO ₂ Emissions (kgCO ₂ /annum)
Development	3,287	22.00	72,303	54,190	126,492

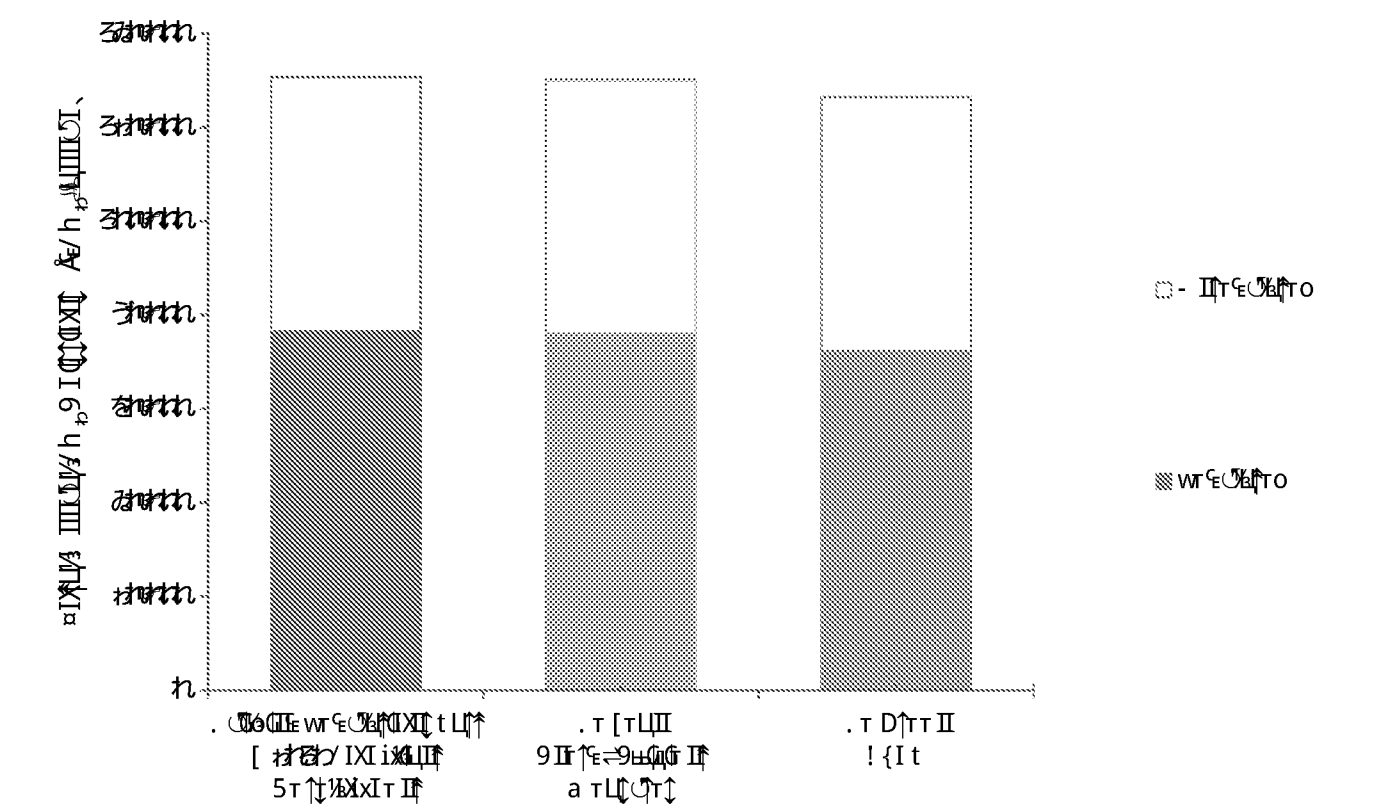
7.4 Green Development Emissions Savings Summary

Table 7.4 provides a summary of the CO₂ emissions savings estimated over the baseline compliant development through application of ASHP; this is also shown in Figure 7.1.

Table 7.4 - CO₂ Emissions Reduction Due to the Introduction of ASHP

	CO ₂ Emissions (kgCO ₂ /annum)	Percentage CO ₂ Emissions Savings
Building Regulations 2013 Part L Compliant Development	76,575	
After energy efficiency measures	75,918	0.9%
After renewable energy savings	72,303	5.6%

Figure 7.1 - Comparison of Building Regulations 2013 Part L Compliant Development and Be Green~Development



7.5 Target Development Energy Reduction

The Arun Council Local Plan sets out a requirement for 10% of the energy used by the development to come from renewable or low carbon sources. Table 7.5 shows the green developments energy use and the heat energy generated by the ASHP.

Table 7.5 - Estimate of Developments Regulated Energy produced by ASHP

	Energy (kWh/annum)	% of developable energy produced from ASHP
Regulated Energy used by green development	264,300	
Heating Energy Generated by ASHP	6,342	2.4%

8 Conclusion

8.1 Proposed Energy Strategy

Scotch Partners have prepared an energy strategy for the proposed development at Saltbox, Bognor Regis in accordance with the Arun council local plan. The strategy follows the energy hierarchy of :Be Lean~, :Be Clean~, :Be Green~ensuring that the main focus is to reduce the demand for energy at source, thereby reducing associated CO₂ emissions.

Proposed building services provision includes for high efficiency plant throughout with the addition of intelligent controls.

There are currently no viable options for connection into existing heat networks. Due to the nature of the proposed development the base heating load would be too low to warrant the use of CHP.

Further to an appraisal of various renewable energy technologies, air source heat pumps has been chosen as the most appropriate option for the proposed offices as they provide a renewable source of heat. Potential exists to connect to a neighbouring solar PV farm subject to further investigation.

8.2 Overall CO₂ Emissions Reduction

As a result of the :Be Lean~, and :Be Green~ measures proposed, an overall saving of 5.6% over regulated CO₂ emissions is achieved. This is summarised in Table 8.1, Table 8.2, and Figure 8.1 below.

Table 8.1~ Development Total Regulated CO₂ Emissions Summary

Stages of the Energy Hierarchy	CO ₂ Emissions (kg CO ₂ /annum)	Percentage (% Reduction in Savings)
Building Regulations 2013 Part L Compliant Development	76,575	
After energy efficiency measures savings	75,918	0.9%
After renewable measures savings	72,303	5.6%

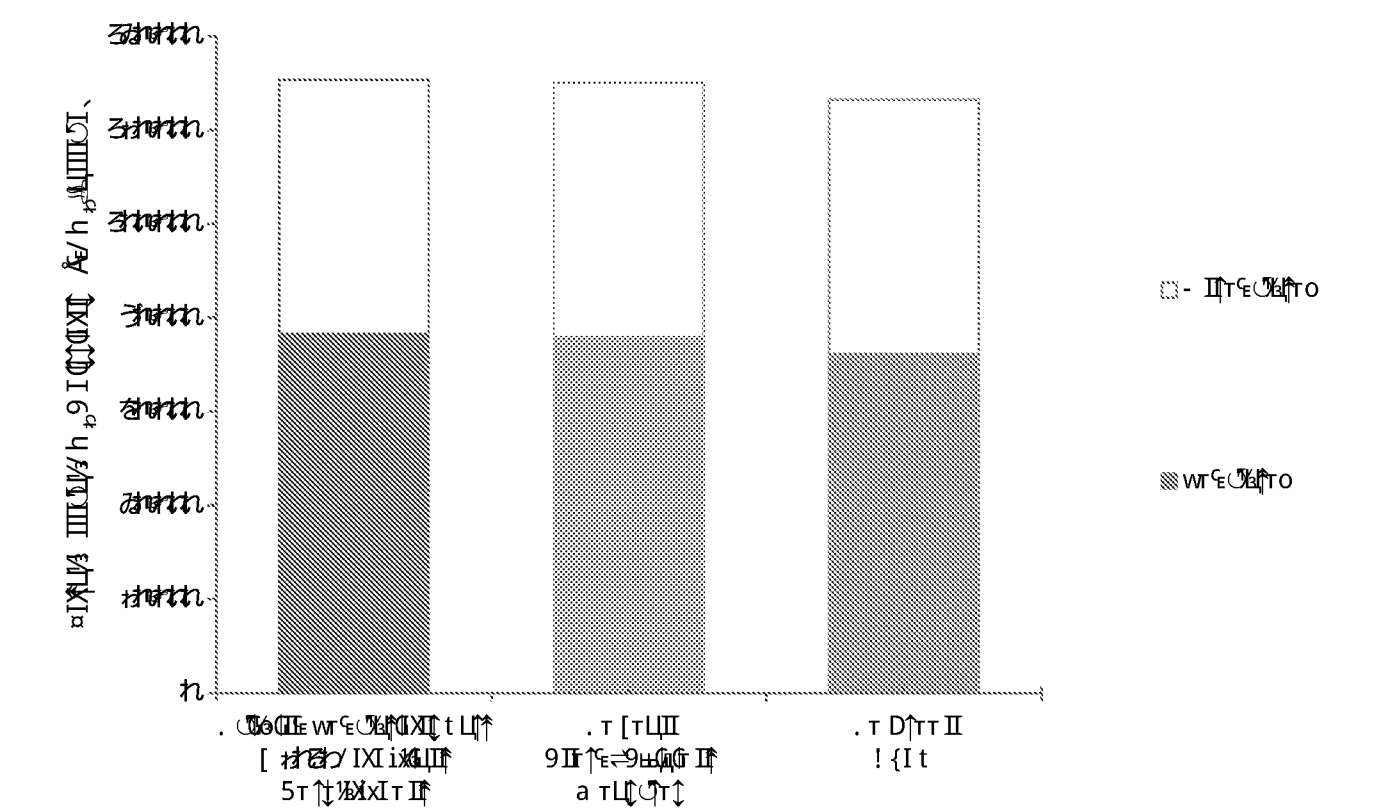
8.3 Overall Renewable Contribution

As a result of the renewable heating energy from the air source heat pump, overall 2.4% of the developments regulated energy use is from renewable energy sources.

Table 8.2~ Arun Council Renewable Energy Target

Arun Council Targets	Energy (kWh/Annun)	Percentage of Development Energy Use
10% Energy from Renewables	26,430	10%
Energy Produced by AS HP	6,342	2.4%

Figure 8.1 ~ Comparison of Building Regulations 2013 Part L Compliant Development, :Be Lean~ Development, :Be Clean~ Development and :Be Green~ Development (regulated emissions)



Appendix 1 – SBEM Model Inputs

Fabric Performance

Model	Office	Warehouse
Air Permeability	10m³/hm²@ 50Pa	10m³/hm²@ 50Pa
Roof U-value	0.25W/m²K	0.25W/m²K
Metal Cladding	Yes	Yes
Floor U-value	0.25W/m²K	0.25W/m²K
Cladding Wall U-value	0.35W/m²K	0.35W/m²K
Metal Cladding	Yes	Yes
Window U-value	2.2 W/m²K	
Frame Fraction	0.17 to 0.3	
T Solar	0.40	
L Solar	0.71	
Roof light U-value		2.2 W/m²K
Frame Fraction		0.1
T Solar		0.55
L Solar		0.60

Lighting

Model	Office	WC	Stairs	Warehouse
Lamp & Ballast Efficacy	LED 100lm/W	LED 80lm/W	LED 80lm/W	LED 100lm/W
Light Output Ratio	1	1	1	1
Photoelectric Control	PH Dimming	-	-	PH Dimming
Occupancy Sensing	Throughout	Throughout	Throughout	Throughout

Ventilation

Model	Office	Warehouse
Main Areas	Mechanical SFP 1.6W/l/s Heat Recovery Efficiency 80%	Natural Destratification Fans
Toilets	Extract 7.2l/s/m² SFP 0.3W/l/s	

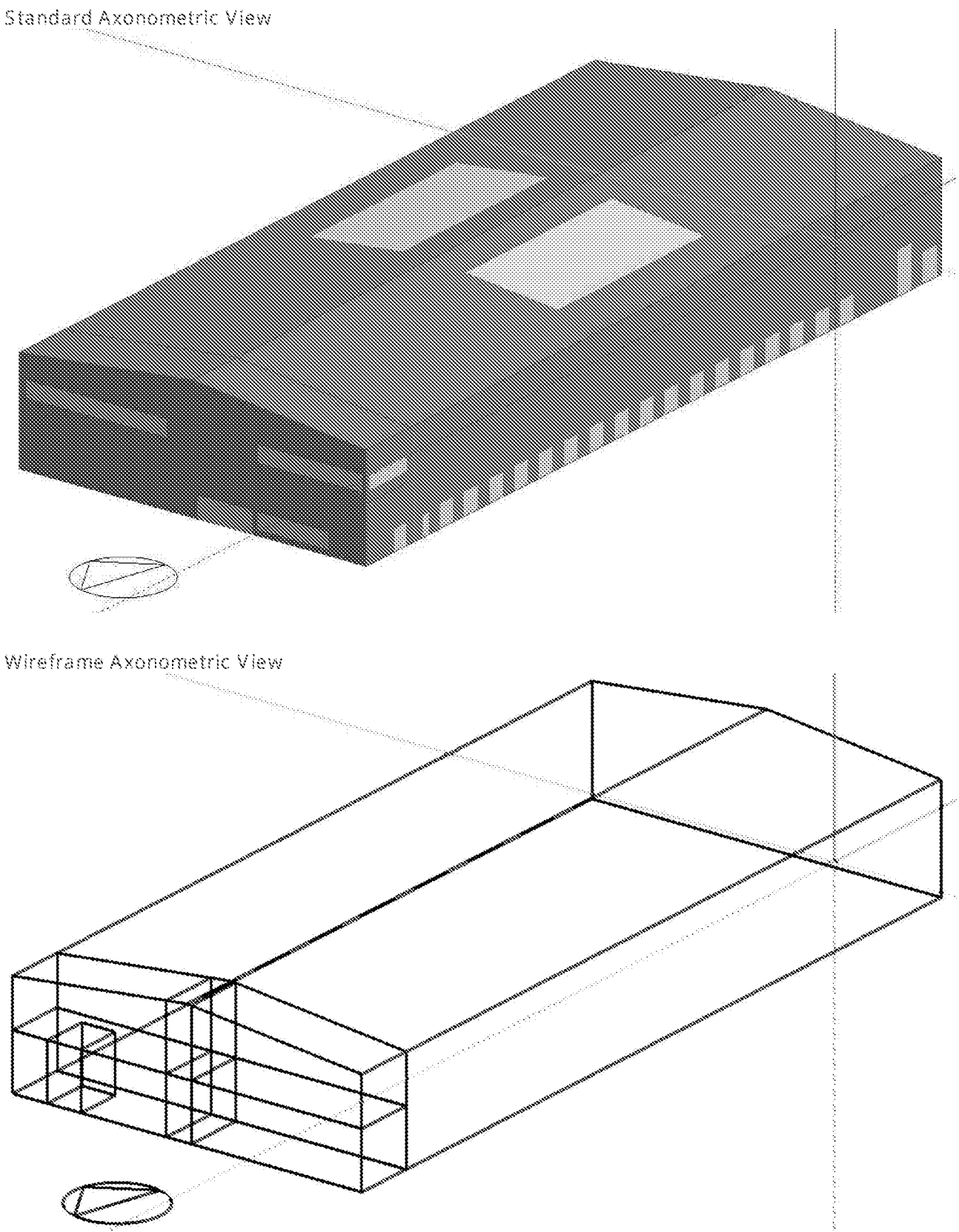
Heating & Cooling

Model	Office	Warehouse
Primary areas	Multi Split ASHP Grid Supplied Electricity SCOP 4.65 EER 3.91 SEER 4.39	Radiant Tube Heater Natural Gas SCOP 93% Radiant Efficiency 60%
Toilets & Stair core	Indirect Heating from Office	

Domestic Hot Water

Model	Office	Warehouse
DHW Throughout	Instant Electric	Instant Electric

Appendix 2 ' SBEM Model Visualisation



Appendix 3 – Data Sources

Model Geometry Inputs

	Comment	
Architect	Mountford Pigott	
Site Orientation	Southern faade 345 degrees from north	Measured from Drawing 1744-F-28-B
SBEM Site Location	Southampton	CL2.1 SBEM Weather Locations Lookup
Plans/GIA's	1744-F-28-B	Master Plan – Block Plan
	1744-F-30-A	Warburtons Unit 2 - Proposed Unit Site Plan
	1744-F-31-A	Warburtons Unit 2 - Proposed Ground Floor
	1744-F-32-A	Warburtons Unit 2 - Proposed First Floor and Roof Plan
Elevations & Sections	1744-F-33-A	Warburtons Unit 2 - Proposed Elevations and Sections
Area Schedule	1744-F-34-A	Warburtons Unit 2 - Schedules

Model HVAC Inputs

	Comment	
M&E Consultant	Scotch Partners LLP	
HVAC & Lighting	Warburtons Standard Depot Specification August 2015	
Example Radiant Heater	InfraSchwank Standard – SCOP 93%, Radiant efficiency 60%	
Example ASHP	Daikin VRV IV – SCOP- 4.65, EER – 3.91, SEER – 4.39	

Reference Documentation

	Comment	
Local Planning Policy	Arun Local Plan 2011 – 2031 – Publication Version October 2014	
Other	Enterprise Bognor Regis Brochure	
Building Regulations	Approved Document L2A	
Building Regulations	2013 Non-Domestic Compliance Guide (NDCG)	

Appendix 4 ´ Be Lean BRUKL Output

Project name

Saltbox Unit 2

As designed

Date: Thu Jul 06 17:35:33 2017

Administrative information

Building Details

Address: Saltbox, Bognor Regis, ,

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.3.a.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.0.3

BRUKL compliance check version: v5.3.a.0

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Scotch Partners LLP

Telephone number:

Address: , ,

Criterion 1: The calculated CO₂ emission rate for the building must not exceed the target

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	23.3
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	23.3
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	23.1
Are emissions from the building less than or equal to the target?	BER ≤ TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	U _a -Limit	U _a -Calc	U _i -Calc	Surface where the maximum value occurs*
Wall**	0.35	0.35	0.35	Warehouse - Warehouse_W_3
Floor	0.25	0.09	0.14	Office Ground Floor - North Office_S_2
Roof	0.25	0.25	0.25	Warehouse - Warehouse_R_11
Windows***, roof windows, and rooflights	2.2	2.2	2.2	Warehouse - Warehouse_G_12
Personnel doors	2.2	2.2	2.2	Warehouse - Warehouse_D_4
Vehicle access & similar large doors	1.5	1.5	1.5	Warehouse - Warehouse_D_9
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

U_a-Limit = Limiting area-weighted average U-values [W/(m²K)]U_a-Calc = Calculated area-weighted average U-values [W/(m²K)]U_i-Calc = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.

** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

*** Display windows and similar glazing are excluded from the U-value check.

N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
m ³ /(h.m ²) at 50 Pa	10	10

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Radiant Tube Heater

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.93	-	0.6	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

2- Air Con Cassette htg & clg

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	3.91	-	-	-
Standard value	0.91*	2.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

1- Instant

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	1	-
Standard value	N/A	N/A

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I	Zone	Standard
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1		
Warehouse - Warehouse	-	-	-	-	-	-	-	-	-	-	N/A
Office Ground Floor - WC	0.3	-	-	-	-	-	-	-	-	-	N/A
Office Ground Floor - North Office	-	-	-	1.6	-	-	-	-	-	0.8	0.65
Office Ground Floor - Stairs & Lift	-	-	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting

Zone name	Luminous efficacy [lm/W]			General lighting [W]
	Luminaire	Lamp	Display lamp	
Standard value	60	60	22	
Warehouse - Warehouse	80	-	-	15737

General lighting and display lighting		Luminous efficacy [lm/W]		
Zone name		Luminaire	Lamp	Display lamp
	Standard value	60	60	22
Office Ground Floor - WC		-	80	-
Office Ground Floor - North Office		100	-	-
Office Ground Floor - Stairs & Lift		-	80	-
				General lighting [W]
				130
				3056
				153

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Warehouse - Warehouse	NO (-5.8%)	NO
Office Ground Floor - WC	N/A	N/A
Office Ground Floor - North Office	NO (-50.5%)	NO
Office Ground Floor - Stairs & Lift	N/A	N/A

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m ²]	3286.5	3286.5
External area [m ²]	8773.5	8773.5
Weather	SOU	SOU
Infiltration [m ³ /hm ² @ 50Pa]	10	7
Average conductance [W/K]	3186.65	2879.82
Average U-value [W/m ² K]	0.36	0.33
Alpha value* [%]	35.16	28.19

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est /Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
100	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	67.81	57.92
Cooling	0.9	1.66
Auxiliary	3.76	0.55
Lighting	11.59	19.11
Hot water	4.22	4.88
Equipment*	31.77	31.77
TOTAL **	88.28	84.12

* Energy used by equipment does not count towards the total for calculating emissions.

** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO₂ Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m ²]	361.5	324.19
Primary energy* [kWh/m ²]	132.61	134.46
Total emissions [kg/m ²]	23.1	23.3

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEFF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Multiburner radiant heaters, [HS] Unflued radiant heater, [HFT] Natural Gas, [CFT] Electricity									
Actual	206.7	166	67.7	0	3.3	0.85	0	0.93	0
Notional	181.2	145.2	58.5	0	0	0.82	0	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity									
Actual	219.9	74.3	68.4	6.3	6.3	0.89	3.28	0.91	4.39
Notional	159.9	150.6	54.2	11.6	3.8	0.82	3.6	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U _{i-Typ}	U _{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.35	Warehouse - Warehouse_W_3
Floor	0.2	0.08	Warehouse - Warehouse_S_2
Roof	0.15	0.25	Warehouse - Warehouse_R_11
Windows, roof windows, and rooflights	1.5	2.2	Warehouse - Warehouse_G_12
Personnel doors	1.5	2.2	Warehouse - Warehouse_D_4
Vehicle access & similar large doors	1.5	1.5	Warehouse - Warehouse_D_9
High usage entrance doors	1.5	-	"No external high usage entrance doors"
U _{i-Typ} = Typical individual element U-values [W/(m²K)]			U _{i-Min} = Minimum individual element U-values [W/(m²K)]
* There might be more than one surface where the minimum U-value occurs.			

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	10

Appendix 5 – Be Green BRUKL Output

Project name

Saltbox Unit 2

As designed

Date: Thu Jul 06 17:31:30 2017

Administrative information

Building Details

Address: Saltbox, Bognor Regis, ,

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.3.a.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.0.3

BRUKL compliance check version: v5.3.a.0

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Scotch Partners LLP

Telephone number:

Address: , ,

Criterion 1: The calculated CO₂ emission rate for the building must not exceed the target

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	22.9
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	22.9
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	22
Are emissions from the building less than or equal to the target?	BER ≤ TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	U _a -Limit	U _a -Calc	U _i -Calc	Surface where the maximum value occurs*
Wall**	0.35	0.35	0.35	Warehouse - Warehouse_W_3
Floor	0.25	0.09	0.14	Office Ground Floor - North Office_S_2
Roof	0.25	0.25	0.25	Warehouse - Warehouse_R_11
Windows***, roof windows, and rooflights	2.2	2.2	2.2	Warehouse - Warehouse_G_12
Personnel doors	2.2	2.2	2.2	Warehouse - Warehouse_D_4
Vehicle access & similar large doors	1.5	1.5	1.5	Warehouse - Warehouse_D_9
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

U_a-Limit = Limiting area-weighted average U-values [W/(m²K)]U_a-Calc = Calculated area-weighted average U-values [W/(m²K)]U_i-Calc = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.

** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

*** Display windows and similar glazing are excluded from the U-value check.

N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
m ³ /(h.m ²) at 50 Pa	10	10

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Radiant Tube Heater

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.93	-	0.6	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

2- Air Con Cassette htg & clg

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	4.65	3.91	-	-	-
Standard value	2.5*	2.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.

1- Instant

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	1	-
Standard value	N/A	N/A

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I	Zone	Standard
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1		
Warehouse - Warehouse	-	-	-	-	-	-	-	-	-	-	N/A
Office Ground Floor - WC	0.3	-	-	-	-	-	-	-	-	-	N/A
Office Ground Floor - North Office	-	-	-	1.6	-	-	-	-	-	0.8	0.65
Office Ground Floor - Stairs & Lift	-	-	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting

Zone name	Luminous efficacy [lm/W]			General lighting [W]
	Luminaire	Lamp	Display lamp	
Standard value	60	60	22	
Warehouse - Warehouse	80	-	-	15737

General lighting and display lighting		Luminous efficacy [lm/W]		
Zone name		Luminaire	Lamp	Display lamp
	Standard value	60	60	22
Office Ground Floor - WC		-	80	-
Office Ground Floor - North Office		100	-	-
Office Ground Floor - Stairs & Lift		-	80	-
				General lighting [W]
				130
				3056
				153

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Warehouse - Warehouse	NO (-5.8%)	NO
Office Ground Floor - WC	N/A	N/A
Office Ground Floor - North Office	NO (-50.5%)	NO
Office Ground Floor - Stairs & Lift	N/A	N/A

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m ²]	3286.5	3286.5
External area [m ²]	8773.5	8773.5
Weather	SOU	SOU
Infiltration [m ³ /hm ² @ 50Pa]	10	7
Average conductance [W/K]	3186.65	2879.82
Average U-value [W/m ² K]	0.36	0.33
Alpha value* [%]	35.16	28.19

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est /Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
100	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	59.95	52.78
Cooling	0.9	1.66
Auxiliary	3.76	0.55
Lighting	11.59	19.11
Hot water	4.22	4.88
Equipment*	31.77	31.77
TOTAL **	80.42	78.98

* Energy used by equipment does not count towards the total for calculating emissions.

** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO₂ Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m ²]	361.5	324.19
Primary energy* [kWh/m ²]	126.56	132.83
Total emissions [kg/m ²]	22	22.9

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEFF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Multiburner radiant heaters, [HS] Unflued radiant heater, [HFT] Natural Gas, [CFT] Electricity									
Actual	206.7	166	67.7	0	3.3	0.85	0	0.93	0
Notional	181.2	145.2	58.5	0	0	0.82	0	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity									
Actual	219.9	74.3	13.4	6.3	6.3	4.56	3.28	4.65	4.39
Notional	159.9	150.6	18.3	11.6	3.8	2.43	3.6	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U _{i-Typ}	U _{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.35	Warehouse - Warehouse_W_3
Floor	0.2	0.08	Warehouse - Warehouse_S_2
Roof	0.15	0.25	Warehouse - Warehouse_R_11
Windows, roof windows, and rooflights	1.5	2.2	Warehouse - Warehouse_G_12
Personnel doors	1.5	2.2	Warehouse - Warehouse_D_4
Vehicle access & similar large doors	1.5	1.5	Warehouse - Warehouse_D_9
High usage entrance doors	1.5	-	"No external high usage entrance doors"
U _{i-Typ} = Typical individual element U-values [W/(m²K)]			U _{i-Min} = Minimum individual element U-values [W/(m²K)]
* There might be more than one surface where the minimum U-value occurs.			

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	10

Scotch Partners LLP
Building Services Engineering | Sustainability | Acoustics

Clerkenwell House
45 Clerkenwell Green
London EC1R 0EB

